

Investigation of Shell Offshore Inc. Hobbit Pipeline Leak Ship Shoal Block 281 January 24, 1990

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Gulf of Mexico
Offshore Louisiana

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Alex Alvarado
Gerald Daniels
Stephen Ledet
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Investigation and Report

Authority

The following investigative panel of Minerals Management Service (MMS) personnel was given the assignment to investigate and to prepare a public report on the pipeline leak discovered on January 24, 1990, in the Ship Shoal Area, Block 281, off the Louisiana coast:

Alex Alvarado	Stephen Ledet
Gerald Daniels	Carl Walker

The panel members were named by memorandum dated May 15, 1990, pursuant to the MMS Manual, Part 640, Chapter 3, Accident Investigations, and to Section 208 (subsections 22d, e, and f) of the Outer Continental Shelf (OCS) Lands Act, as amended in 1978.

Procedures

The accident investigation panel members met at the MMS Gulf of Mexico OCS Regional Office in New Orleans, Louisiana, on February 28, 1990. Each member presented and discussed information he had gathered as a result of his investigation. The panel chairman, Alex Alvarado, considered all the facts and data presented and then requested from the involved companies additional information necessary to the investigation. This additional information was submitted to the chairman and distributed to the other panel members. The panel met subsequent to their review of the additional information on September 11, 1990, to discuss their findings further.

Introduction

Background

The Shell Pipe Line Corporation (SPLC) is the pipeline right-of-way (ROW) holder and operator of the Cougar Pipeline System, which gathers liquid hydrocarbon production from Federal oil and gas leases in the South Timbalier, Ship Shoal, and Ewing Bank Areas for delivery into the Central Gulf Gathering System (MMS Royalty Measurement Operations System No. 26.0). This production is transported to Union Operating Partners Limited's (UNOCAL) oil gathering station in Ship Shoal Block 208 and is metered and transported shoreward via Unocal Pipeline Company's (UPLCO) 18-inch White Cap Pipeline.

The sales points for royalty purposes are established at the Federal oil and gas lease injection points. The metering of incoming production at Ship Shoal Block 208 provides UPLCO with delivery measurement data only for the Cougar Pipeline. The Cougar Pipeline System originates at Shell Offshore Inc.'s (SOI) South Timbalier Block 300 Platform A and transports production from the following sources:

- SOI's leases in South Timbalier Blocks 292, 295, 300, and 301. Production from these leases is delivered to South Timbalier Block 300 Platform A, via a 6-inch pipeline from South Timbalier Block 301 Platform B.
- British Petroleum Company's (BP) Ewing Bank Block 826 Platform A, via BP's 12-inch pipeline, ROW OCS-G 10110.

- ARCO Oil and Gas Company's (ARCO) Ship Shoal Block 332 Platform A, via ARCO's 6-inch pipeline, ROW OCS-G 8058.
- SOI's Ship Shoal Block 259 Platform JA, via SOI's 4-inch Hobbit Pipeline, ROW OCS-G 10065.

The leak occurred on the 4-inch Hobbit Pipeline where it connects subsea with the 12-inch Cougar Pipeline in Ship Shoal Block 281. The ROW for the Hobbit Pipeline was granted to SOI on June 3, 1988, under 30 CFR 250 regulations; the pipeline was constructed shortly thereafter. The Hobbit Pipeline and the Cougar Pipeline System are operated under the regulatory jurisdiction of the U.S. Department of Transportation (DOT), pursuant to 49 CFR 195 regulations, Transportation of Hazardous Liquids by Pipeline. (For a map of the complete system see Attachment 1.) DOT did not conduct an investigation of this incident.

**Description
Of Incident**

On January 24, 1990, at 10:20 a.m., a helicopter pilot flying in the Ship Shoal Area reported a heavy oil slick 25 miles by 15 miles in size at latitude 28°17.7' North and longitude 90°51.8' West. The pilot immediately reported the slick to the National Response Center (NRC). The NRC assigned Control No. 1691 to the report. Personnel at SOI's South Timbalier Block 300 Platform A overheard the report to the NRC and dispatched a helicopter to investigate. The SOI confirmed the slick sighting and surmised that the source of the leak was the Cougar Pipeline System. The entire Cougar Pipeline System was shut down in an orderly

fashion by 1 p.m. on January 24, 1990. The MMS Gulf of Mexico (GOM) Area Office of Field Operations was notified at 1:40 p.m. by SPLC. At that time, SPLC was uncertain if the source of the spill was the 12-inch Cougar Pipeline or SOI's 4-inch Hobbit Pipeline, which connects to the Cougar Pipeline System in the general area of the spill site.

At 1:30 p.m., SOI's Oil Spill Contingency Plan (OSCP) was activated. The SOI established an Oil Spill Response Command Center, and the resources referenced in their OSCP were made available. By 3 p.m., MMS personnel from the MMS Gulf of Mexico Houma District Office were on location and reported the slick to be 2 miles by 7 miles in size with the sheen scattered and broken.

Following preliminary tests of the system, SOI had determined that the probable leak location was on the 4-inch Hobbit Pipeline between the Ship Shoal Block 259 Platform JA and the subsea tie-in (SSTI) point with the 12-inch Cougar Pipeline.

Cal-Dive International in Morgan City, Louisiana, was contracted to locate and repair the leak. In the early afternoon of January 25, 1990, an inspection of the SSTI by Cal-Dive International revealed that a 2-inch valve on the 4-inch SSTI assembly had been separated from a 4-inch by 4-inch by 2-inch reducing weld-tee. The valve and the parted flange were found on the sea floor approximately 18 inches from the SSTI assembly (see Attachment 2).

The 4-inch tie-in valve on the Hobbit Pipeline was then closed, and the 12-inch Cougar Pipeline was tested for leakage. No leakage was observed, and the unaffected portions of the 12-inch Cougar Pipeline System were returned to service. The total shut-in time of the 12-inch Cougar Pipeline was 29 hours.

The damaged portion of the SSTI assembly was disconnected at the corresponding flanges and brought to the surface for repairs. When the section was brought to the surface, a pink Poly Pig was found tightly wedged in the spool piece (see Attachment 3). After the Poly Pig was removed, the 2-inch girth weld where the break had occurred was found to be cut out. A 2-inch Schedule 80 weld cap was welded to the newly installed outlet on the tee. The new weld was radiographically inspected and found acceptable. The spool piece was reinstalled and leak tested to 400 pounds per square inch (psi) for 40 minutes. The 4-inch Hobbit Pipeline was returned to service at 6 p.m. on January 26, 1990.

**Oil-Spill
Reports and
Trajectory
Analysis**

The oil slick was initially sighted near latitude 28°17.7' North and longitude 90°51.8' West. This unconfirmed sighting indicated the oil spill to be 25 miles by 15 miles in size with a combination of heavy and rainbow sheens. Following this report, SPLC, MMS, and Placid Oil Company (Placid) made slick observations. The MMS and Placid personnel both reported the slick to be in the vicinity of Ship Shoal Block 281 and approximately 2 miles by 7 miles in size with the sheen

Ship Shoal Block 208 were compared to the sum of the run tickets from Ewing Bank Block 826, South Timbalier Block 300, Ship Shoal Block 332, and Ship Shoal Block 259 by SPLC to obtain a system balance for the month of January 1990. The SPLC advised further that, after the spill, it began calculating daily losses and gains using the daily meter logs at the measurement sites to obtain a daily system balance. The SPLC developed this balancing system to assist in the detection of problems within the system. However, SPLC suggested that the monthly balance is more accurate because it reflects net oil volumes as opposed to the daily tabulations, which are prepared using gross fluid data.

In addition to these check meter systems, SPLC relied on pressure sensors with high- and low-pressure detection capabilities to alert the operators to system upsets. These sensors were provided during installation of the original system and additional pipelines.

**Possible
Oil Volume
Spilled**

Early estimates of the quantity of oil spilled, based on slick sightings on January 24 and 25, had varied from 88 to 400 bbl of oil on the surface of the water.

A balance of the Cougar Pipeline System for the entire month of January 1990, however, showed a shortage of 17,375 bbl of oil and condensate.

This monthly balance is the total registered throughput at the turbine meter at Ship Shoal Block 208, compared with the sum of the net oil runs measured through royalty ACT units from the contributing leases. The SOI

believes that this is the most accurate estimate of the spilled volume because net oil deliveries are compared to the registered volume at Ship Shoal Block 208, after an adjustment for an observed 0.12 percent underregistration by the turbine meter.

Furthermore, SOI provided an analysis of the possible volume of oil that could have escaped the system through a 2-inch circular opening. The analysis indicated flow rates ranging from 33 barrels per hour (bph) with the Poly Pig tightly wedged against the opening, to 550 bph with no flow restriction present. As indicated by the daily system balance tabulations, a spill beginning on January 12 at midday and ending on January 24 at midday would span about 290 hours. Therefore, based on this analysis, estimates of the volume of oil spilled would range from 9,570 to 159,000 bbl.

Finally, the volume of the spill could not have exceeded 197,000 bbl because this volume represents the total deliveries into the Cougar Pipeline System from January 12 through January 24.

Panel Investigation and Findings

The MMS accident investigation panel members independently investigated the following aspects of this incident:

- System measurement balance data, supplied by SPLC and UPLCO.
- Significant unidentified oil spills reported during January 1990 in the area near the Cougar Pipeline System.
- Conclusions generated by an analytical model formulated to calculate the theoretical volume spilled, considering the system pressure and flow rates, etc.
- Photographic evidence of the affected section of the pipeline.
- Onsite inspections of records and equipment located on the platforms serviced by the Cougar Pipeline.
- The most likely surface spill path as developed by the trajectory analysis model, using local meteorological data and prevailing weather conditions during the time of the leak.
- Daily work logs and associated data concerning the locating and repair of the damaged pipeline, as compiled by SOI for the period of January 25 through 26, 1990.

- Conclusions of a metallurgical and failure analysis conducted on the damaged 2-inch flange.
- The SPLC's routine operation logs for the Cougar Pipeline System for December 1989 and January 1990.

System Measurement Balance

Table 1 lists the actual losses and gains of the Cougar Pipeline System throughput, as calculated by the investigating panel members using run tickets from each input source and the readings from the check meter at Ship Shoal Block 208 for the beginning of 1990. (Graphical representation of this data can be found in Attachment 4.)

Upon reviewing this data, considerable losses, indicative of an upset in the system, can be seen for the 12-day period from January 12, 1990, through discovery of the leak on January 24, 1990. This prompted the panel to investigate the high probability that oil had leaked from the pipeline for several days prior to its discovery. Although this information was available to SPLC, the huge shortage was not discovered until tabulation of the data after January 31, 1990. Despite the fact that the Cougar Pipeline System had a slight tendency to show a shortage during the first quarter of Calendar Year 1990, the losses shown in Table 1 lead the panel to believe that a significantly larger amount of oil had been spilled than was present on the water surface on January 24, 1990.

Table 1. Tabulation of Daily (Losses) and Gains in the Cougar Pipeline System

January*		February†		March‡		April		May	
Date	bbl	Date	bbl	Date	bbl	Date	bbl	Date	bbl
1	(470)	1	(22)	1	551	1	16	1	88
2	299	2	175	2	(175)	2	(30)	2	81
3	115	3	(1575)	3	(46)	3	(55)	3	473
4	31	4	1099	4	(824)	4	(34)	4	(869)
5	(106)	5	(342)	5	519	5	(173)	5	70
6	286	6	559	6	(144)	6	348		
7	(72)	7	(488)	7	(181)	7	(477)		
8	220	8	(58)	8	(127)	8	(84)		
9	(29)	9	117	9	(252)	9	(36)		
10	(156)	10	227	10	(90)	10	(134)		
11	84	11	(476)	11	32	11	210		
12	(378)	12	(2)	12	117	12	(326)		
13	(828)	13	(1176)	13	(2)	13	56		
14	(5965)	14	693	14	(239)	14	(167)		
15	(1070)	15	191	15	291	15	(137)		
16	(1663)	16	(145)	16	53	16	(460)		
17	(1040)	17	169	17	463	17	114		
18	(1193)	18	(219)	18	(574)	18	(21)		
19	(1603)	19	(182)	19	(100)	19	43		
20	(1243)	20	831	20	109	20	(260)		
21	(1047)	21	(1063)	21	(43)	21	448		
22	1548	22	(474)	22	(132)	22	(721)		
23	(541)	23	333	23	(104)	23	(114)		
24	(385)	24	(182)	24	(259)	24	136		
25	(298)	25	(16)	25	(172)	25	163		
26	(253)	26	355	26	(492)	26	(165)		
27	106	27	(616)	27	257	27	(226)		
28	(352)	28	(1180)	28	(294)	28	(207)		
29	135			29	76	29	(37)		
30	(227)			30	(256)	30	(127)		
31	(22)			31	(117)				

*Calculated from daily meter log readings after the spill occurred.

†From February 1 to March 10, the figures were calculated manually from daily meter log readings.

‡After March 10, the figures were calculated by data entered in a personal computer.

**Oil-Spill
Reports and
Trajectory
Analysis**

In an effort to substantiate the theory of an ongoing spill, the investigative panel researched reports of unidentified spills in the near-vicinity of Cougar Pipeline System for the period of time immediately preceding the leak's discovery. The panel found the following spills for which a source could not be identified and that could be attributed to the damage to the Hobbit Pipeline:

<u>Date</u>	<u>Size</u>	<u>Appearance</u>	<u>Location</u>	<u>Moving</u>
1) 1/17/90	1/2 mi x 3/4 mi	Light Sheen	Ship Shoal Block 253	SE
2) 1/18/90	200 yd x 1/2 mi	Brown	Ship Shoal Block 222	SE
3) 1/19/90	25 mi x 5 mi	Rainbow to heavy	Ship Shoal Block 222	SE
4) 1/20/90	1 mi x 2 mi	Rainbow	Ship Shoal Block 239	SE
5) 1/23/90	1 mi x 150 ft	Sheen	Ship Shoal Block 214	SE

The prevailing weather data for this period and a trajectory analysis simulating both a continuous leak and batch release of oil during the 12-day period were also reviewed. The plotting of the trajectory information and the unidentified sightings supported the theory that the pipeline had probably intermittently spilled varying quantities of oil over a period of several days (see Attachment 5).

**Factors
Affecting
the Surface
Appearance
and Delaying
Detection
of the Leak**

During the removal and repair of the damaged section of pipe, workers found a 6-inch Poly Pig tightly lodged into the 4-inch Hobbit pipeline. The break in the damaged pipe was blocked by the Poly Pig, and it appeared that the pig would only allow oil to leak when the pressure in the system exceeded the pressure necessary to dislodge the pig temporarily. Therefore, considering the large fluctuations in pressure and flow rates common in the Cougar Pipeline System, the Poly Pig would permit only intermittent batch releases, which would make locating or identifying the problem by surveillance ~~only~~ quite difficult.

The routine operating logs were examined to determine the originating point and launch time for the 6-inch Poly Pig. All indications are that the pig was launched from Ship Shoal Block 332 Platform A on January 10, 1990, at 1 p.m. The estimated run time from ARCO's Ship Shoal Block 332 Platform A to the Hobbit subsea connection is approximately 25 to 36 hours, allowing for temporary hangups in the system and fluid by-pass in the 12-inch Cougar Pipeline.

The likely scenario is that the damage to the SSTI assembly occurred just prior to the pig reaching the 4-inch SSTI in Ship Shoal Block 281. The pressure differential across the SSTI was greater than the linear pressure differential within the 12-inch Cougar Pipeline System, thereby allowing the 6-inch Poly Pig to be forced into the 4-inch SSTI assembly some time during January 12th.

**Analytical
Pipeline
Leak Model**

The pipeline system and leak were modeled by a computer program called PIPEFLOW-2 developed by Chevron Geosciences Company.

PIPEFLOW-2 is a highly generalized pressure and flow simulator that allows the user to calculate pressure losses and flow rates. Two analytical models were used to determine the theoretical flow rate of the oil spill.

The first model was an unobstructed 2-inch hole. Four separate sets of data were used to determine a flow rate through a 2-inch orifice created when the 2-inch valve was broken from the weld-neck flange. The flow rates calculated using this model were between 53.2 bph and 550 bph.

The second model simulated the effects on the flow rate of a 6-inch Poly Pig tightly lodged in the 4-inch pipeline. The flow rate obtained from this model was in the neighborhood of 33 bph.

**Investigation
of System
Input Sources**

Immediately following the repair of the Hobbit Pipeline, an MMS investigative panel member visited the platforms serviced by the Cougar Pipeline System to investigate the leak detection capabilities at each platform. At the time of the spill, the primary means of leak detection was the pipeline pressure safety low sensor (PSL).

It was determined that the pressure fluctuations within the Cougar Pipeline System (20 to 500 psi) and the hydrostatic pressure of the seawater at the

SSTI (92 psi), as well as the PSL setting at SOI's platform in Ship Shoal Block 259 (34 psi), made the detection of a leak of any size completely impossible.

Additionally, the Poly Pig lodged in the line allowed pipeline pressures to remain well above the pressure necessary to interrupt flow by the PSL on each platform.

The secondary method of leak detection was the biweekly pipeline patrol as required by 49 CFR 195. A review of the patrol records shows that the line was patrolled on January 10, 1990, without a leak sighting; the next scheduled patrol was on January 24, 1990, the day of the leak discovery.

At the time of the leak, no other methods were being used to detect leaks within the system. However, during the platform investigations, SPLC informed the MMS representative that a daily meter balance program was initiated to identify and investigate shortages within the system.

Cause of Leak

On January 25, 1990, a few minutes after leaving the dive bell, the diver found the source of the leak. The 2-inch ANSI¹ 900 flange and valve had been broken off a 4-inch by 4-inch by 2-inch reducing weld-tee on the SSTI assembly. The flange and valve were lying on the seafloor approximately 18 inches from where they were originally attached. According to the

¹American National Standards Institute

repair crew, the broken flange and valve were in "excellent condition."

There were some scratches in the paint, but it was not possible to determine if they occurred during installation or during retrieval of the valve on January 25, 1990.

The diver reported that the SSTI assembly was covered with approximately 12 inches of sand and deteriorated pieces of burlap bags. The sand bags that were originally over the top of the manifold were rotten and disintegrated. He noted that three parts of the assembly were protruding above the sand cover and surmised that the actuator on top of the 2-inch valve had also been exposed prior to the spill. He reported that the sand had been scoured out of an area approximately 2 feet in diameter where the valve had been attached. The scour appeared to have been caused by flow from the break.

The break in the weld-tee was fairly clean in the heat-affected zone and almost perpendicular to the center line of the flange. The repair crew believes the damage was caused by an anchor or a cable of a fishing net that hooked the 2-inch valve handle and broke it off. However, there was no indication of anchor scars in the vicinity of the SSTI.

The SOI, in conjunction with Shell Development Company, performed a detailed laboratory examination of the failed materials and concluded the following:

"Our analysis of the failure indicates that large tensile or bending loads would have been necessary to fracture the flange; the load from the cantilevered components would be insufficient to have caused the failure. Although we saw no evidence of any mechanical damage to the flange, it is possible that the cantilevered ball valve may have been pulled by something such as an anchor."

The fracture at the weld neck was in the area of minimum cross-section. Wall thickness measurements made approximately 1/4 inch from the fracture varied between 0.140 inch and 0.199 inch. The nominal thickness of a Schedule 40 flange is 0.154 inch.

The entire fractured surface was at 45° to the axis of the flange, suggesting an overload-type failure. No evidence of any flat fractures, typical of what might be encountered in fatigue, could be found (see Attachment 6).

Conclusions

- The damage to the pipeline occurred sometime prior to January 24, 1990, when the slick was investigated and the leak was found. The daily balances, as well as launch and run times of the Poly Pig, indicate the leak probably began on or about January 12, 1990.
- The Poly Pig lodged in the opening helped to reduce the total volume of oil spilled.
- The most probable volume of oil spilled was 14,423 bbl. This figure was obtained using the sum of the system balance differences (15,408 bbl), less a 0.5 percent underregistration of the total deliveries into the Cougar Pipeline System from January 12 through January 24 at the Ship Shoal Block 208 check meter (985 bbl). The 0.5 percent underregistration was evident in the February, March, and April 1990 system balance tabulations.
- The metallurgical and failure analysis, as well as the initial diver's survey, identified the cause of the damage to the pipeline as external forces exerted on the 2-inch valve.
- Due to the absence of anchor scars around the SSTI assembly and the lack of external damage to the 2-inch valve, the consensus of the panel is that the 2-inch valve was protruding from the sand covering and was snagged by cable from a fishing net or anchor.

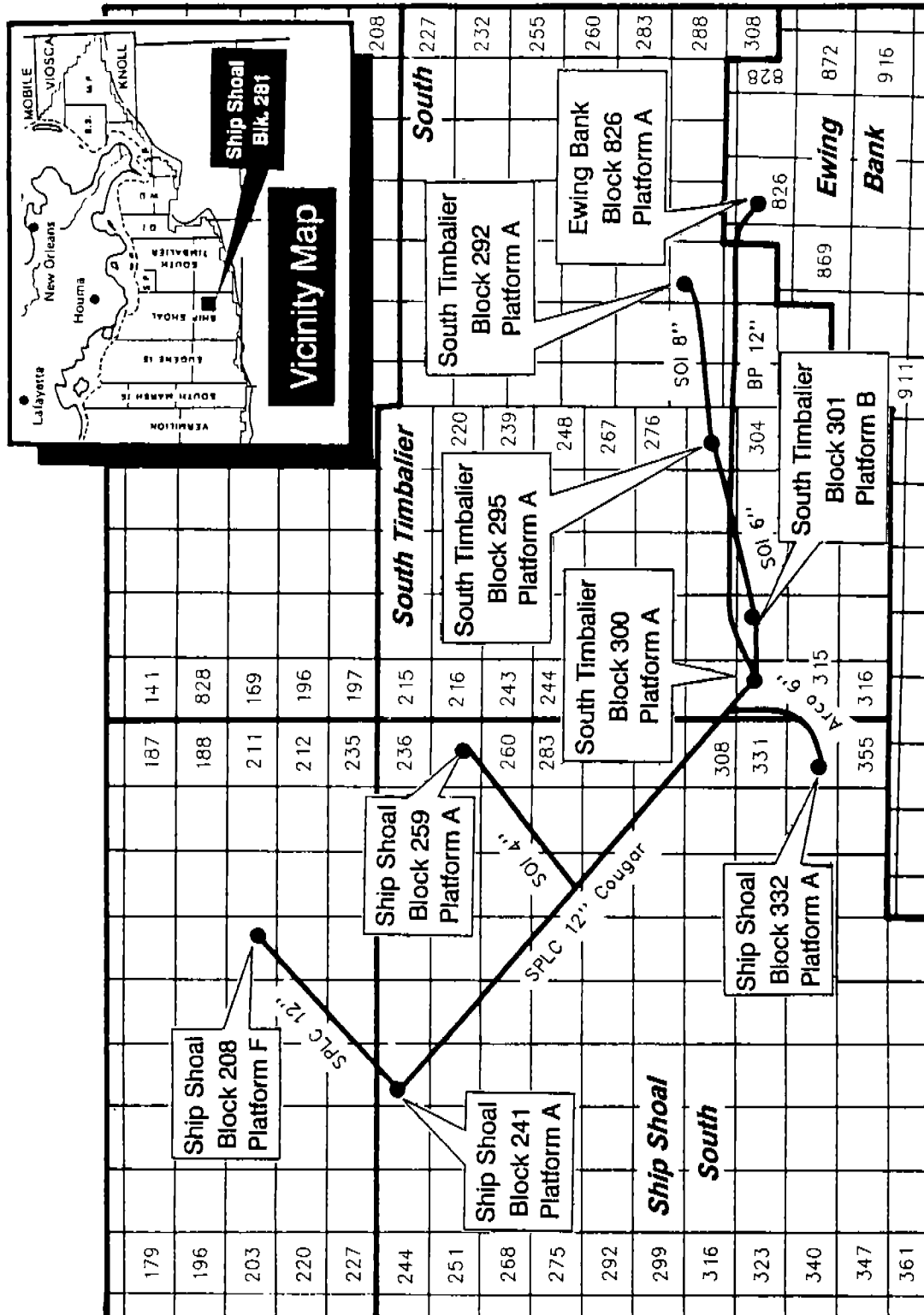
- It was also noted during this investigation that the GOM Regional Office of Field Operations had recorded several recent instances of SSTI appurtenances being damaged by external forces due to a lack of proper cover. This information, as well as deterioration of the Hobbit subsea assembly coverage only one and one-half years after construction of the pipeline, suggests better protection for subsea appurtenances is necessary.
- The low-pressure sensors on the Cougar Pipeline System were set at pressures such that the detection of a leak of any size would have been impossible.
- Low-pressure sensors as a means of leak detection are not usually effective.
- If the run tickets and delivery readings associated with the Cougar Pipeline System had been balanced on a routine basis at a minimum frequency of once per day, a shortage, identifying a problem warranting investigation, would certainly have been discovered.

Recommendations

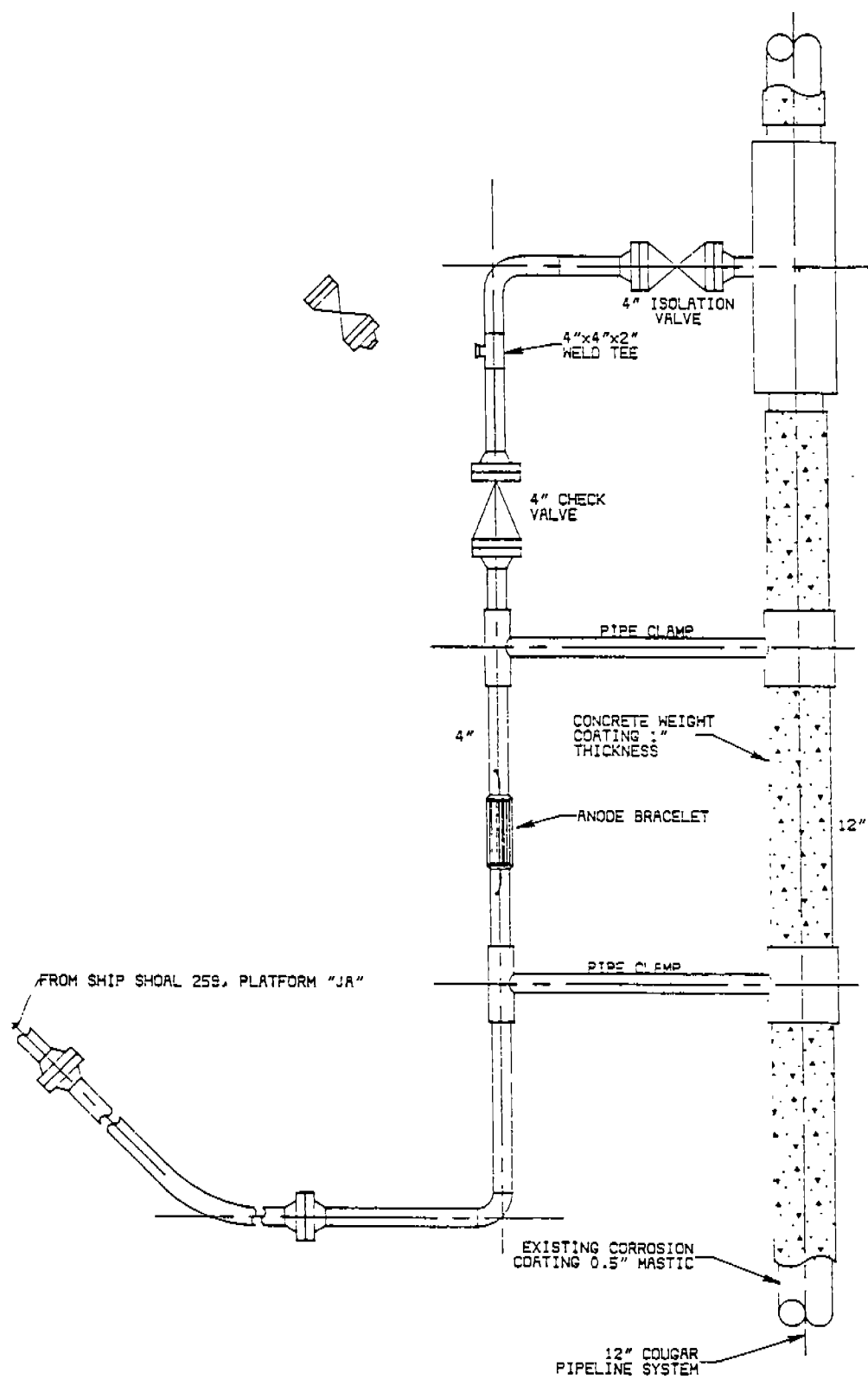
- The MMS should investigate the applicability of pipeline leak detection systems other than low-pressure sensors.
- The MMS should modify current regulations to require improved protection of subsea appurtenances and periodic inspection of all subsea appurtenances to ensure adequate protection from damage.
- The MMS should immediately issue a Safety Alert to notify all lessees and pipeline ROW holders of the potential problems with protecting subsea appurtenances.
- The SPLC and other operators associated with the Cougar Pipeline System should immediately implement an automated or manual system of routinely balancing deliveries and receipts at a frequency greater than once daily.

Glossary

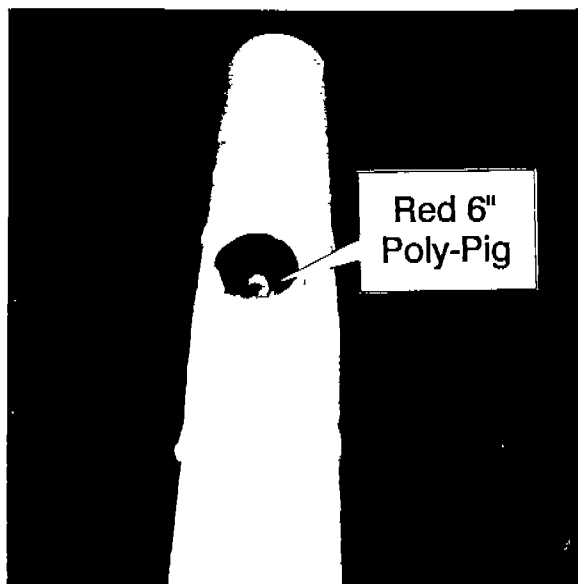
Poly Pig	A bullet-shaped device made of polyurethane flexible foam inserted in a pipeline for the purpose of sweeping the line clean of water, rust, or other foreign matter.
Spool Piece	A short section of pipe specially cut to join the ends of two pipelines.
Subsea Tie-in (SSTI)	The assembly used to connect two or more pipelines under water.
Weld-tee	A manufactured fitting used to connect pipe by means of welding.



Cougar Pipeline System

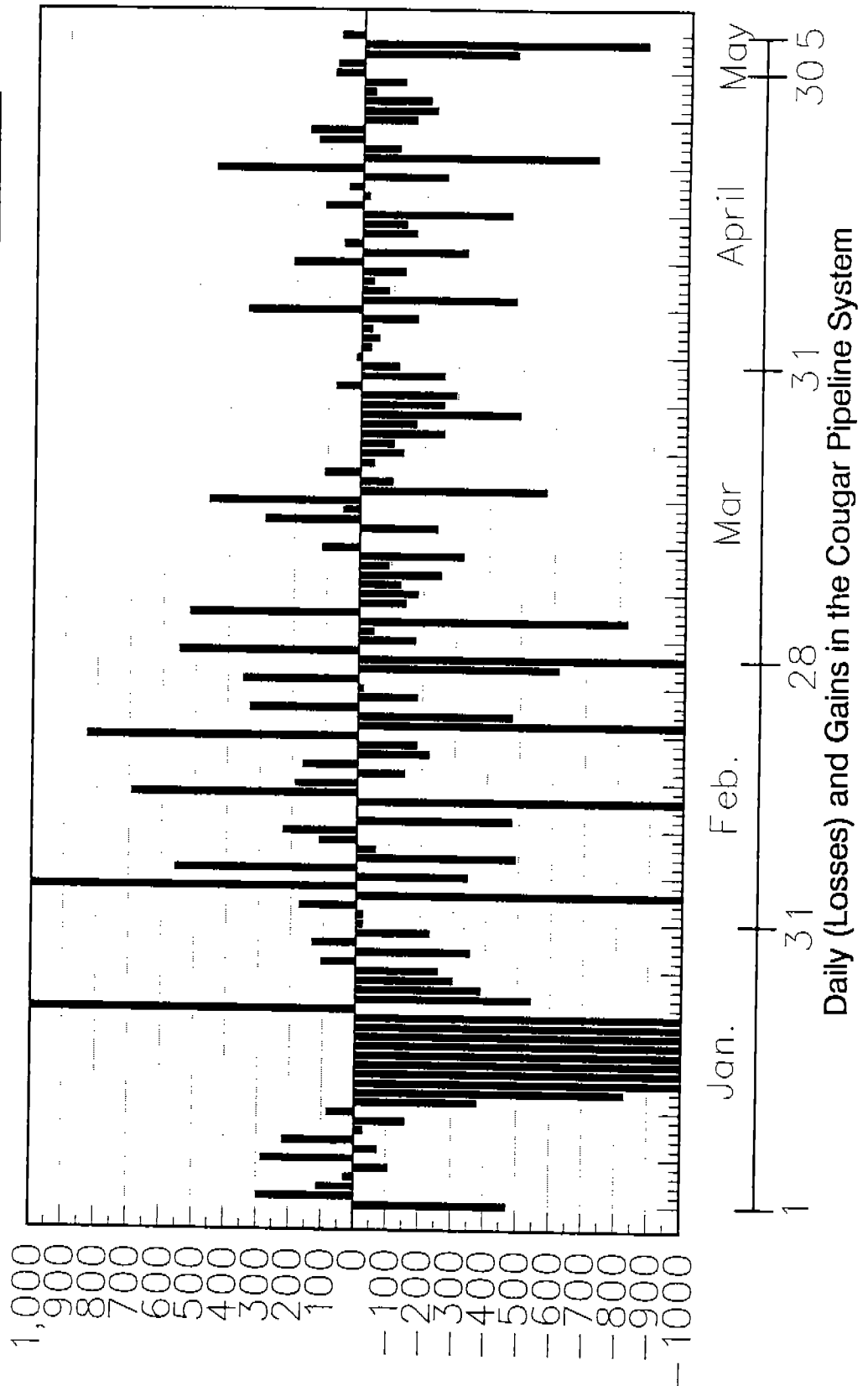


Hobbit Subsea Tie-in Assembly



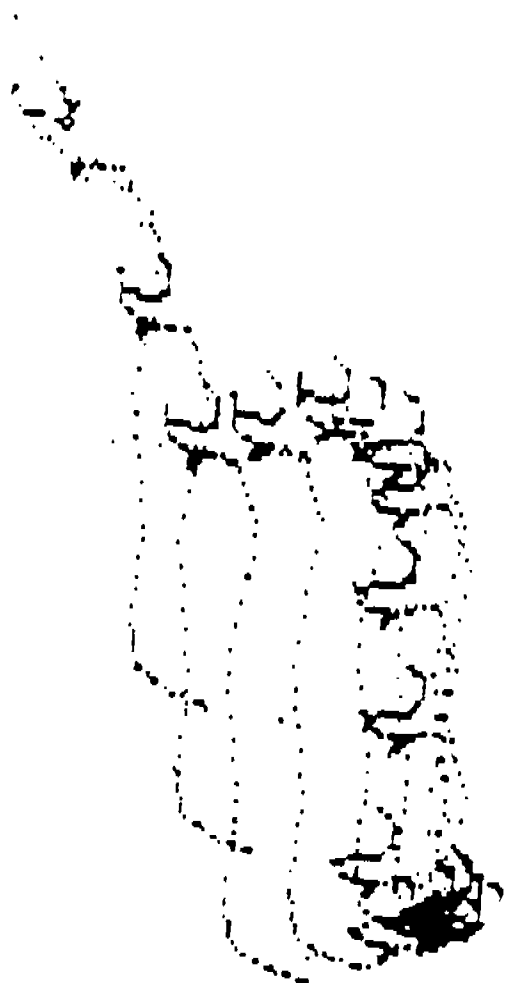
Damaged Section Showing Red 6-inch Poly-Pig

Tabulation Of Daily Losses And Gains In The Cougar Pipeline System



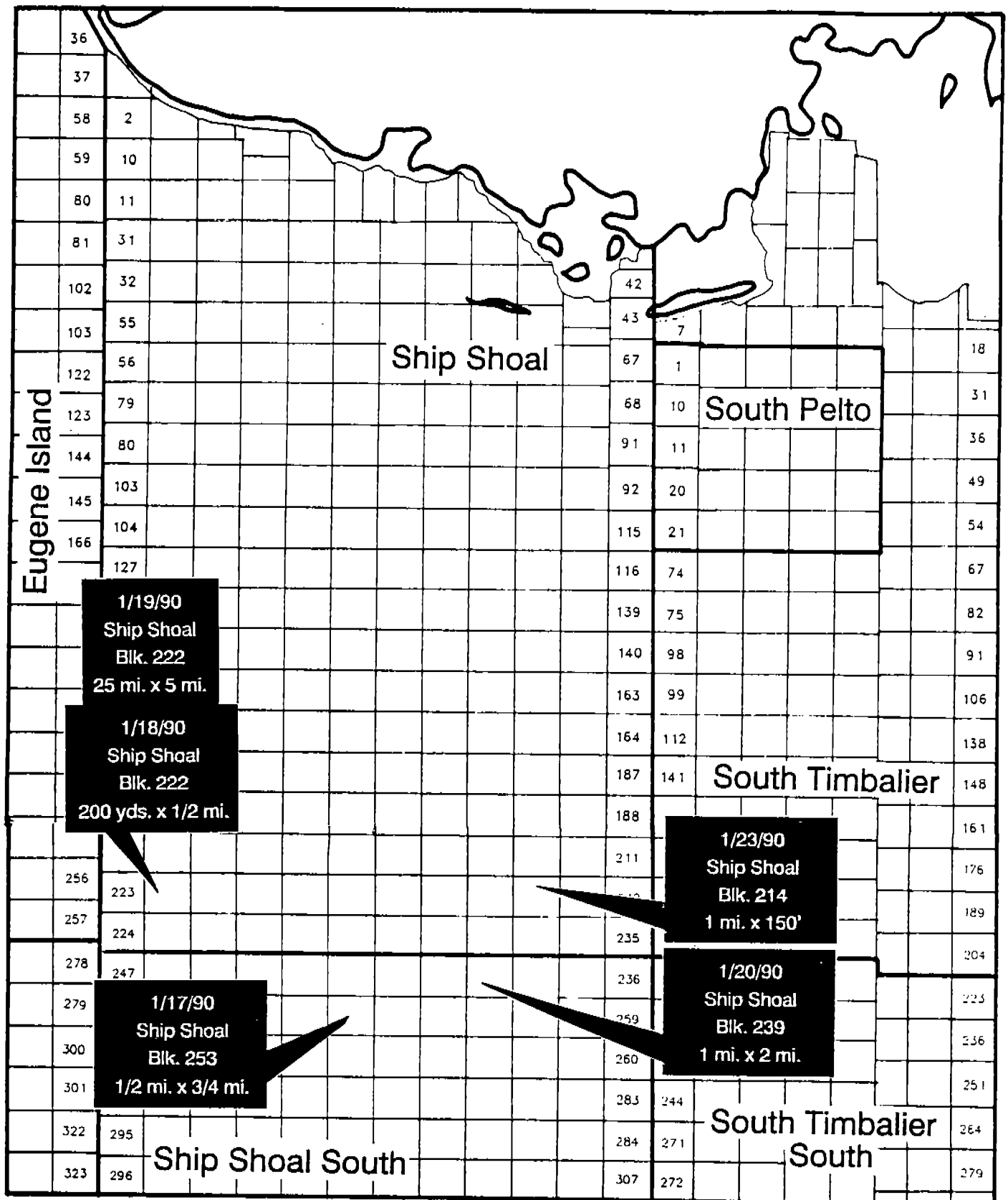
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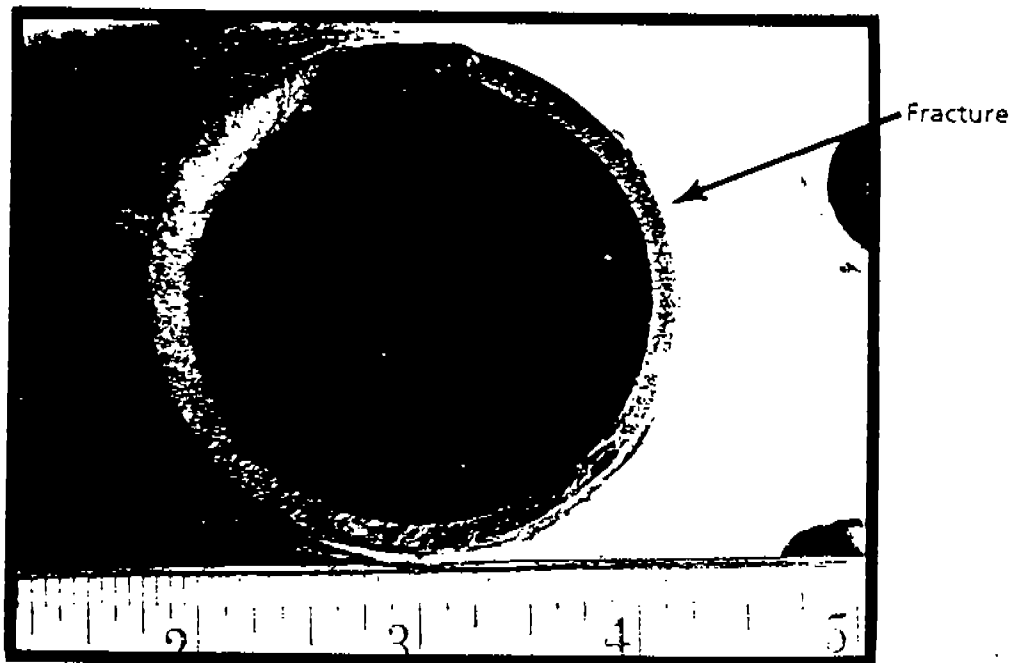
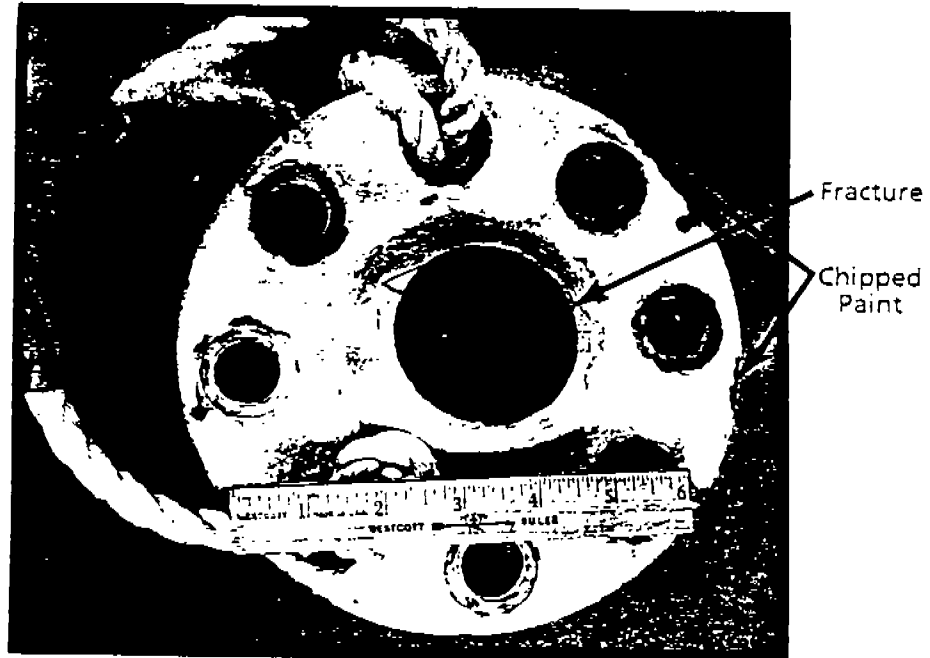


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Projected Trajectories of Cougar Pipeline Oil Spills



Fractured Flange from Subsea Manifold, Cougar Pipeline